MIT JOI 2012

24 January 2012

Zachary Casas, Henna Jethani, Elizabeth Jones,
Anne Marinan, Daniel Rankin, Christopher Rossi,
Lindsay Sanneman, Christopher Trigg

Outline

- **Introduction and Program Overview**
- **What we Learned**
  - Commercial Crew Program
  - Public Affairs and Constellation Project (Orion)
  - Ground Processing, Constellation Operability Database software tool
  - Technology for Exploration and SRB Recovery Boats
  - Shuttle Transition and Retirement Office
  - Engineering and Technology Directorate
  - Launch Services Program
  - ISS Ground Processing and Researching Project Office
- **Closing Remarks**

January Operational Internship (JOI) Overview

- Started in 2004 at the suggestion of then Deputy Administrator Fred Gregory during a visit to MIT
- Run through MIT by Raji Patel and Dr. Jeff Hoffman, currently funded through the Massachusetts Space Grant Consortium

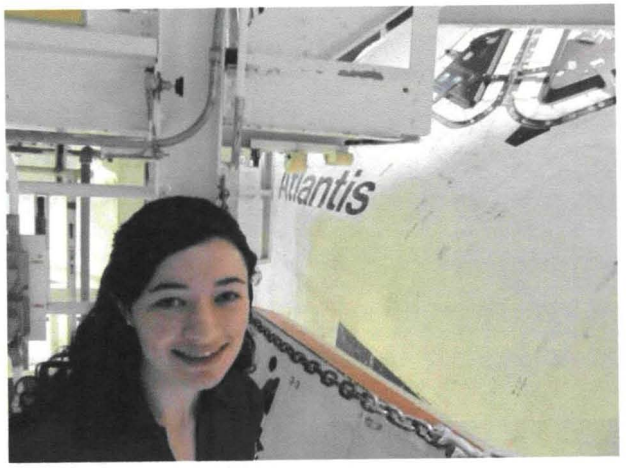
- 8 students from MIT Aero/Astro
- 2.5 weeks in KSC during Independent Activities Period
- Tours, briefings, demonstrations across KSC
- Design versus operability

Day 2: Commercial Crew Program

Annie Marinan

My Experience

- **Background**
  - First year Master's student in AeroAstro
  - Space Systems Laboratory
- **Why I came**
  - Florida in January
  - Opportunity to see inner workings of KSC
  - Curiosity about end of Shuttle Program and human exploration (expand on satellite and planetary missions focus)
- **What I got out of it**
  - View of everything – more than most employees get to see
  - Appreciation for scope and details of space exploration
  - Tips and pieces of advice along the way



Day 2: Commercial Crew Program
Overview

- **Introduction to CCP**
  - Partner Integration
  - Program Control and Integration
  - Systems Engineering and Requirements
  - Systems
- **Tour of LC39A**

Day 2: Commercial Crew Program
Overview

- **Post-shuttle approach to sending crew and cargo to LEO**
  - 2010 NASA Authorization Act
  - Focusing on safe, reliable, cost-effective methods
- **Productive working relationships between NASA and commercial partners**
  - Insight/Oversight model
- **Strategic Plan**
  - CCDev1 (Commercial Crew Development) – initial design concepts
  - CCDev2 – current stage – maturing design elements
  - Integrated Design Phase – announce opportunities this year – entire systems
  - DTEC (design, test, evaluation, certification) Phase 2, initial ISS missions

Day 2: Commercial Crew Program
Design vs Operability

- **Commercial companies responsible for design**
  - Paradigm shift for NASA
  - Insight/oversight role for NASA
- **NASA provides high-level requirements and advice**
  - Only hard requirements (at this stage) come from ISS interface as the final destination
  - Stringent NASA standards not imposed – industries use own standards with NASA guidance
  - *Crew Transport and Operations Standards* – covers training and simulation
    - Document provided to get companies to start thinking about these elements
- **Launch and Recovery Systems**
  - Transforming KSC into flexible 'spaceport'

Day 2: Commercial Crew Program
Past, Present, Future

- **Completely different role and approach for NASA**
  - Space Act Agreements rather than Cost Plus or Fixed Price contracts
  - Requirements controlled at program level – reviewed and critiqued by partners
  - Support and advise partners while preserving competitive approach
  - Relatively small department – flexible and efficient
- **Elements from past programs**
  - Checks and balances, Technical/Program board structure, independent assessments
  - Trying to incorporate as much existing architecture as possible (e.g. launch platforms, facilities)
- **Challenges for the future**
  - Politics and logistics with commercial integration structure
  - Closing on business cases
  - Developing new systems vs updating existing systems

Day 2: Commercial Crew Program
Acknowledgements

- Commercial Crew Program (FA)
- Tyrell Hawkins
- Tracey Drake
- Karen Lucht
- Pam Zeitler
- Cheryl Malloy
- Pat Hanan
- Melissa Jones

Day 3: Public Affairs and Constellation (Orion)

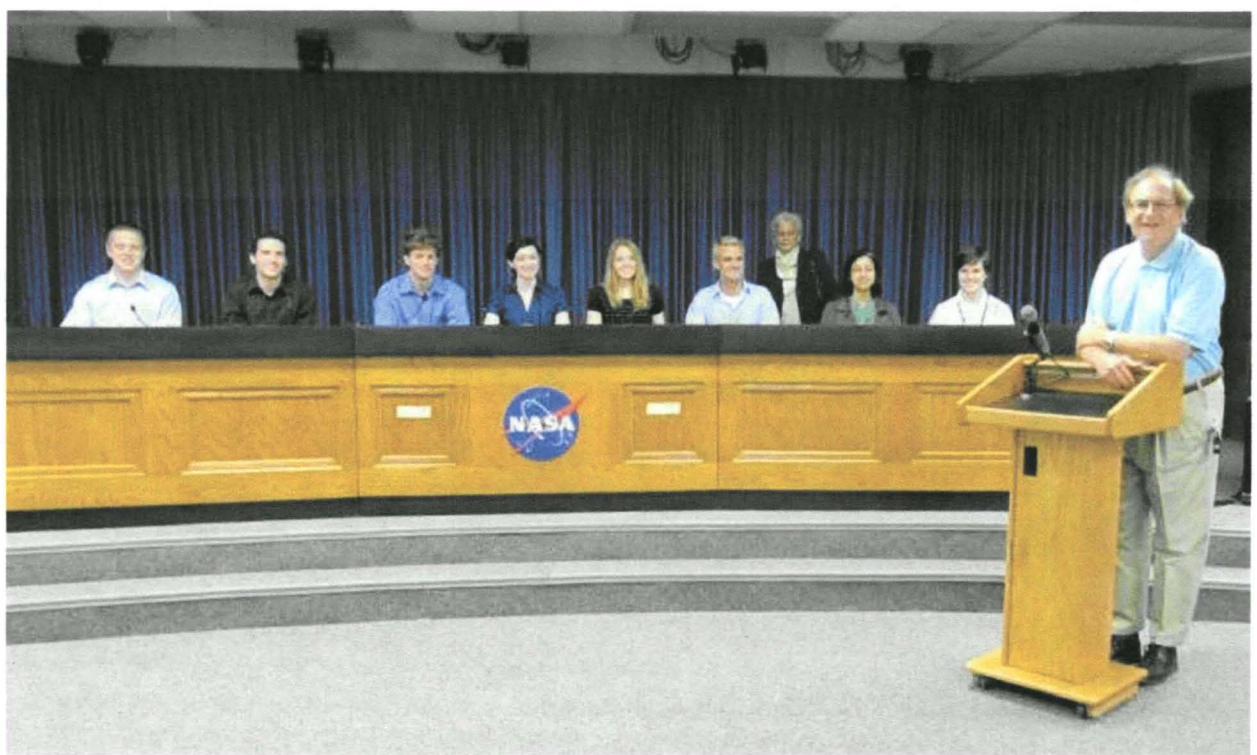
Chris Rossi

My Experience

- **Background**
  - 2nd year Master's student
  - Starting career in human spaceflight at Draper Labs in Houston in Guidance, Navigation, Control (GNC) in July
- **Why I came**
  - Gain understanding of KSC culture and organization
    - Previously interned at JPL and JSC
  - Learn as much as possible
- **What I got out of it**
  - Brought US space program to life
    - Flight hardware!
  - Ground and launch operational considerations with key examples
  - Value of using existing infrastructure and resources

Day 3: Public Affairs
Overview

- **Tour of press site**
  - Press conference room
  - Television studio
  - Audio and visual equipment rooms
  - Video archives



Day 3: Public Affairs
Past, Present, Future

- **Flexible resource for any launches and exploration activities**
- **Able to support to other NASA centers and commercial companies**
- **Accommodates large media groups**
  - Typically ~500 media for Shuttle launch
  - Max of ~3200 for Apollo 11
  - Similar maximum for SLS exploration launches?

Day 3: Public Affairs
Acknowledgements

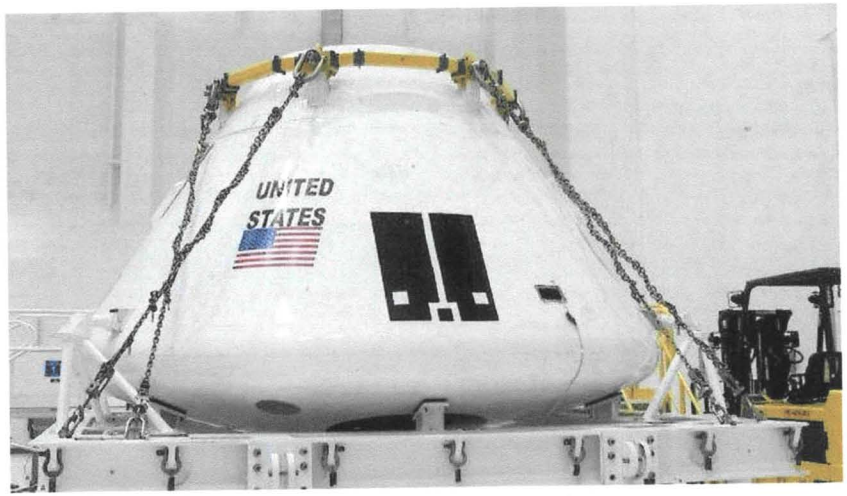
- George Diller
- William Rauckhorst
- Alysia Lee
- Public Affairs team

Day 3: Constellation (Orion)
Overview

- **Tours of MPPF (Multi-Payload Processing Facility) and O&C (Operations and Checkout) Buildings**
  - MPCV (Multi-Purpose Crew Vehicle) to be integrated and vacuum tested in O&C
  - MPPF to be used for MPCV pre-flight and post-flight processing
  - Saw MPCV test article used in 2011 LAS (Launch Abort System) test

Day 3: Constellation (Orion)
Design vs. Operability

- **Processing time drives vehicle design (e.g. battery life)**
- **Mobile launcher provides short pad time (~5 days)**
- **Ground processing: Design -> Simulate -> Mock-up**
  - MPCV and white room mock-ups for interface testing, crew emergency egress testing
  - Influence MPCV design early on
  - More focus on operability than Apollo?
- **MPCV will be used infrequently compared to Shuttle**
  - Design may dominate operability



Day 3: Constellation (Orion)
Past, Present, Future

- **Use of existing infrastructure**
  - MPPF
  - O&C renovated
    - Vacuum chambers from Apollo era to be used
    - New hardware integration tools
    - New lean practices and air bearings to increase efficiency
  - Pad 39B (without fixed or rotating service structures)
- **Selective reuse**
  - MPCV will reuse expensive inner components (e.g. avionics), but not outer structure
- **Looking forward to Exploration Flight Test 1!**

Day 3: Constellation (Orion)
Acknowledgements

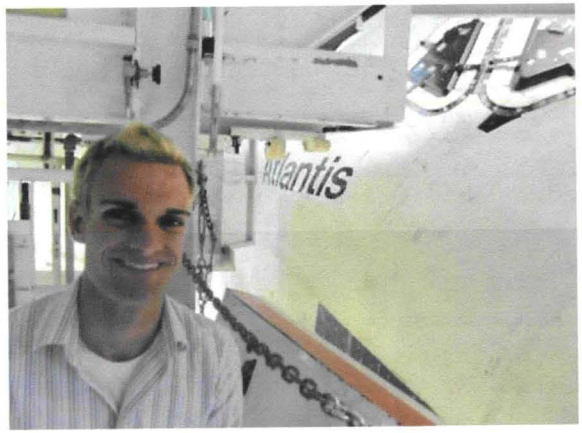
- Doug Lenhardt
- Mr. Quinn
- Orion ground processing team

Day 4: Ground Processing Directorate

Chris Trigg

My Experience

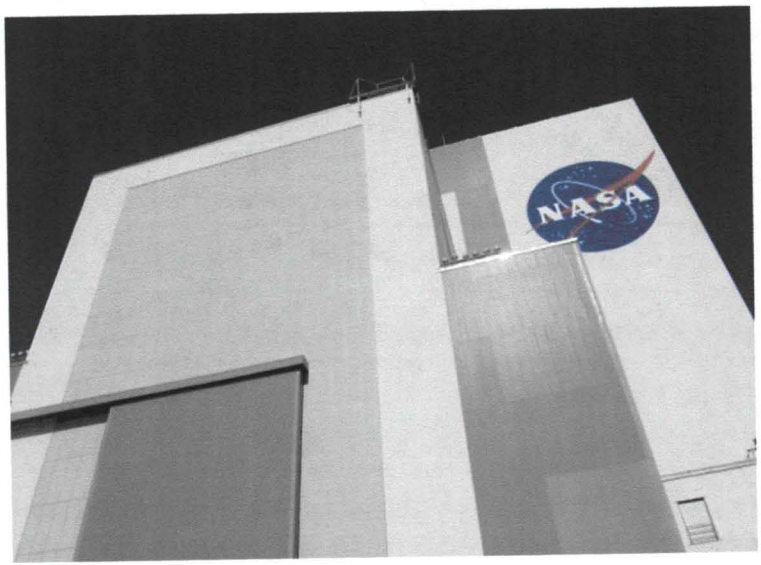
- **Background**
  - First year Master's student in AeroAstro, PARTNER Laboratory (Air Transportation, Noise, and Emissions Reduction)
  - Recent switch from environmental engineering
- **Why I came**
  - Interest in getting a more complete and detailed understanding of the shuttle program (mission cycle, ground infrastructure, etc.)
  - Wanting a broader knowledge of space systems (as opposed to aeronautical research focus)

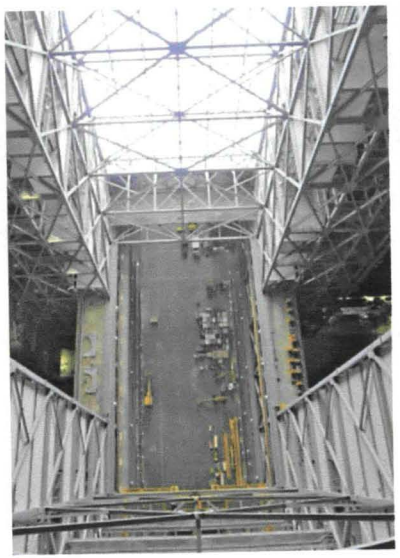


- **What I got out of it**
  - Employee experience and advice on career path development
  - Extraordinary new appreciation for the detail and complexity involved in all of NASA's programs
  - Once in a lifetime tours

Day 4: Ground Processing Directorate
Overview

- **GPD Overview Presentation**
- **VAB Tour**
- **Presentations by 21st Century Ground Operations**
  - Ground Operations Planning Database
  - Integrated Launch and On-Orbit Assembly Risk Analysis



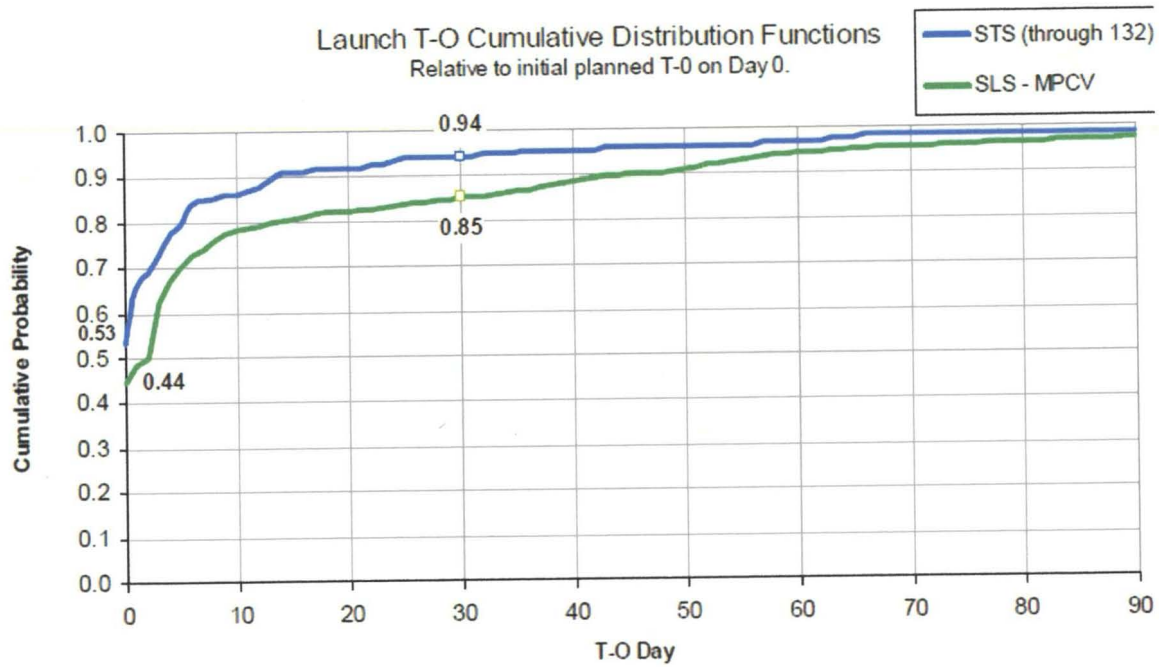


Day 4: Ground Processing Directorate
Design vs. Operability

- **High-level**
  - Trade-off of operability vs. design often program specific (Shuttle vs. one-off planetary mission)
  - Flexibility – Fundamental requirements independent of actual design allow for accommodation of multiple designs/iterations (launch tower umbilical)
- **Mid-level**
  - GOPDb – Operations planning tool, designed for ease of operations
- **Low-level**
  - Building maintenance and sustained operability (VAB max floor loads, crane certification, vertical lift door access)

Day 4: Ground Processing Directorate
Past, Present, Future

- **VAB**
  - Door height design constraint for future launch vehicles
  - History of reuse with modification
- **Ground Operations**
  - Capability driven with block upgrades
  - Modernization of existing ground infrastructure
- **SLS LOM Risk Analysis for NEA DRM**
  - Launch delay risk models based on STS
  - SLS well below 95% success target for launch w/in 30 days



Cates, Grant et al. Launch Assembly Reliability Analysis for Human Space Exploration Missions. 2012 IEEE/AIAA Aerospace Conference, March 2012, Big Sky, MT.

Day 4: Ground Processing Directorate
Acknowledgements

- Kathryn Barger
- Scott Kerr
- VAB Crane Operations Team
- Cliff Lanham and 21st Century Ground Operations Team
- Dr. Grant Cates

Day 5: Technology for Exploration

Henna Jethani

My Experience

- **Background**
  - Sophomore in AeroAstro
  - Two summer internships at NASA Ames
    - Martian Paleochannels
    - Nanotubes and Nanowires for photovoltaic solar cells
- **Why I came**
  - Wanted to see a big space systems-oriented NASA center
  - Learn about NASA's transition from the shuttle program
  - Experience a team internship
- **What I got out of it**
  - Made me less confused about what I want to do
  - Determined to continue with aerospace engineering
  - Put what we're learning in school into perspective

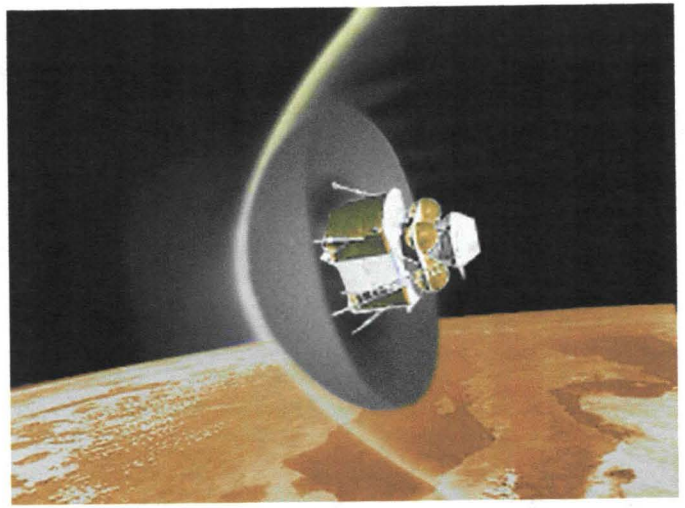
Day 5: Electrostatics at the SLSL
Overview

- **Electrostatic separator**
  - Prevents potential problems as a result of lunar dust
  - Design phase
- **Regolith Derived Heat Shields**
  - Three possible methods
  - Concept development phase
- **Funding**
  - Need to find cost-effective and efficient methods to carry out projects

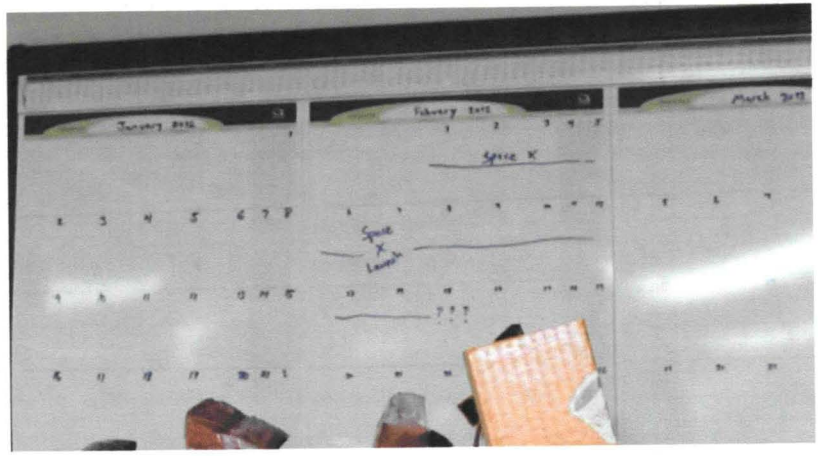
Day 5: Liberty Star and Freedom Star
Overview

- **SRB Recovery**
- **Small Crew**
- **Toured the Freedom Star and Hangar**
- **Operability vs. Design**
  - Multi-purpose
  - Boats made to last
  - SRBs demonstrate good design

Day 5: Technology for Exploration
Past, Present and Future



- **Electrostatics at the SLSL**
  - Electrostatic separator in testing phase
  - Regolith Derived Heat Shields have not reached the testing phase
  - Both projects working to develop cost-effective methods



- **Freedom Star and Liberty Star**
  - Main purpose was SRB recovery
  - Now they help commercial companies
    - Radar-tracking
    - Advising
  - Training for Orion recovery
  - Recover SLS SRBs (tentative - if reusable)

Day 5 Acknowledgements

- **Technology for Exploration Discussion:**
  - Dr. Carlos Calle
  - Dr. Michael D. Hogue
- **Freedom Star and Liberty Star:**
  - Captain David S. Fraine

Day 6: Shuttle Transition and Retirement

Zachary Casas

My Experience

- **Background**
  - Junior in the AeroAstro Department
- **Why I came**
  - To learn how the aerospace industry operates
  - To learn where NASA is going next

- **What I got out of it**
  - Got to see amazing things that a lot of employees don't even get to see
  - Appreciation for all of the different people and offices that work to make manned and unmanned spaceflight possible

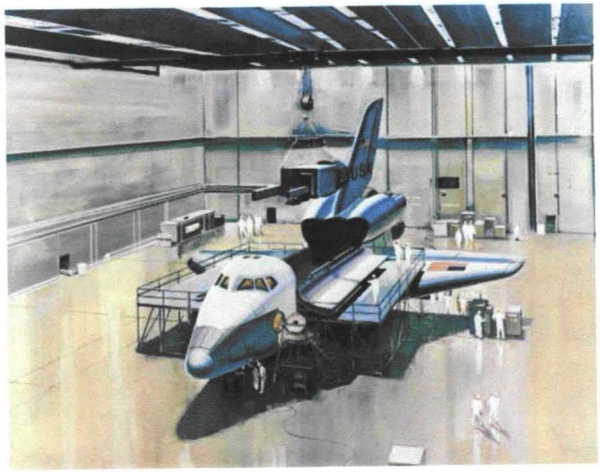
Day 6: Shuttle Transition and Retirement

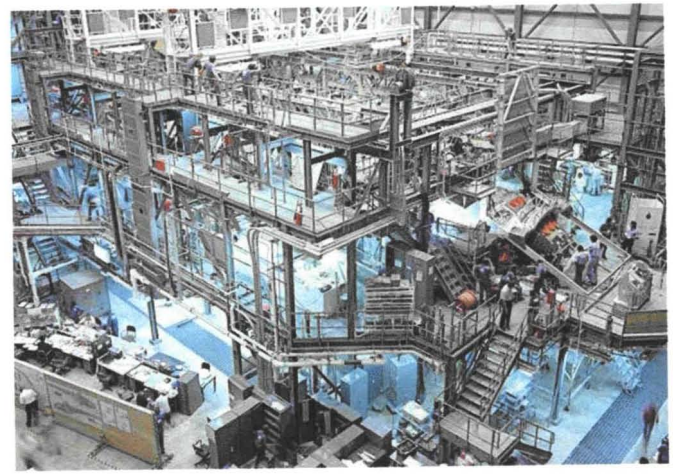
Overview

- KSC Shuttle Transition & Retirement Briefing
- Tour of OPF 1 and 2
- Tour of ISS Storage Facility
- Tour of NSSD (NASA Spacecraft Servicing Depot)
- Meet and Greet with Janet Petro

Day 6: Shuttle Transition and Retirement
Design vs. Operability

- Original idea of servicing the Shuttle was simple, but in reality is much more complex
- Designed Orbiters, SRMs, and SRBs to be reusable
- Designed facilities so that after the Shuttle is retired, they can be reused and kept for future work





Day 6: Shuttle Transition and Retirement
Past, Present, Future

- **Present**
  - There was no planned transition phase from Apollo, but NASA is working on smoothly transitioning from the Shuttle Program
  - OPF 3 is currently sublet to Boeing
- **Future**
  - Returning to the use of capsules for manned space flight with Orion MPCV
  - About 70% of the real property used for the Shuttle will be kept and changed for future uses
  - OPF 1 and OPF 2 are going to other companies, but the negotiations have not yet been finished

Day 6: Shuttle Transition and Retirement
Acknowledgments

- Deborah Smith
- George Jacobs
- Kathryn Barger
- Jeff Wheeler
- Batman and Robin
- NSSD Team
- Wendy Neuerburg
- Janet Petro

Day 7: Engineering and Technology Directorate

Daniel Rankin

My Experience

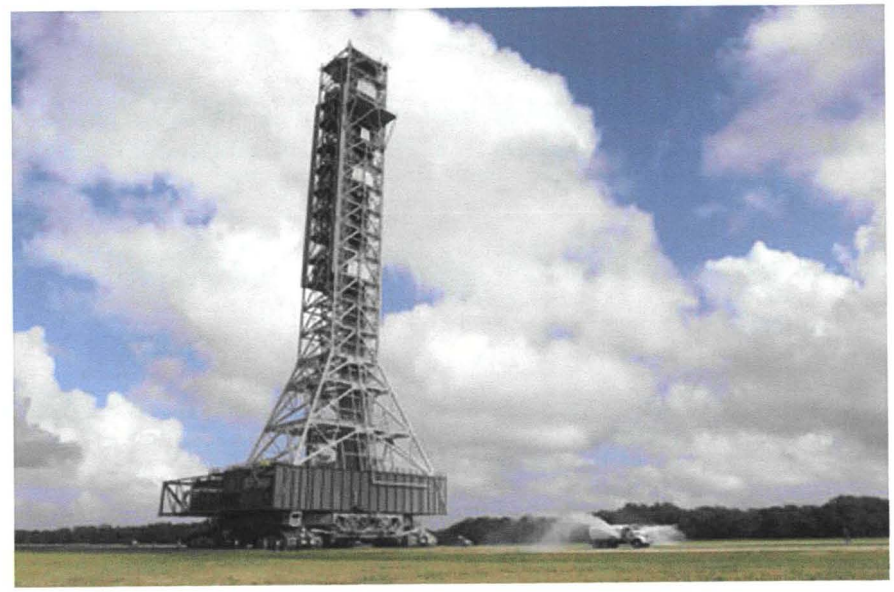
- **Background**
  - Junior in AeroAstro
  - Research in MIT's Man-Vehicle Lab on Bio-Suit technology
- **Why I came**
  - NASA is an icon of space travel
  - To see how KSC operates and interacts as a whole
- **What I got out of it**
  - Space travel requires much more than just the flight vehicle
  - NASA is undergoing transition but still moving full speed ahead

Day 7: Engineering and Technology Directorate
Overview

- Chief Engineers Office
- Surface Systems Office
- Systems Hardware Engineering
- Applied Physics
- Prototype Development
- Technical Management

Day 7: Engineering and Technology Directorate
Chief Engineers Office -- Mobile Launcher

- NASA's Shuttle mindset is changing to systems with more compatibility
- Design constraints had to fit existing structures
- Exhaust Port designed to be modified
- Umbilicals put on rails to accommodate design changes for Constellation



Day 7: Engineering and Technology Directorate
Surface Systems Office

- **Concerns about erosion on landings**
  - Experience from Apollo missions
- **Sandblasting nearby structures**
  - Need to think about landing areas
  - Use Excavators to make berms to protect settlements and structures
- **Lance Blade**

Day 7: Engineering and Technology Directorate
Systems Hardware Engineering

- Generic control systems for launch and recovery from Constellation
- Based on commercial products for flexibility and future support
- Core system and interfaces for specific rockets
- Visual PLC (programmable logic controller)

Day 7: Engineering and Technology Directorate
Applied Physics

- Schlieren System
- Water vacuum for Shuttle tiles
- Hail/defect monitor for external tank
- Ultrasonic telescope for locating leaks
- Magnets for shock absorption and mobility
- RESOLVE

Day 7: Engineering and Technology Directorate
Prototype Development

- **Large role in troubleshooting**
- **Composites**
  - Lack of information
  - Time consuming and expensive
- **Rapid Prototyping**

Day 7: Engineering and Technology Directorate
Technical Management

- **Flight hardware performance vs ground operations**
- **Operational improvements from past programs**
  - Orbiter infrastructure
  - ISS
    - Airlock
    - Workstand configuration flexibility
    - Equipment pack installation

Day 7: Engineering and Technology Directorate
Acknowledgments

- Patrick Simpkins
- Hector Delgado
- Jack Fox
- Todd Steinrock
- Dwayne Perry
- Bob Youngquist
- Roger Matthews
- Ian Kappes

Day 8: Launch Services Program

Lindsay Sanneman

My Experience

- **Background**
  - Sophomore in the AeroAstro Department
  - Space Systems Lab
    - MicroMAS Satellite
    - Zero Robotics High School Programming competition

- **Why I came**
  - Always loved NASA and the space program
  - Wanted to learn more about NASA's operations and its direction after the shuttle program
- **What I got out of it**
  - Got me excited about space exploration again
  - Helped me see real world applications in the midst of technical studies
  - Allowed me to see many different aspects of NASA's operations and how they fit together

Day 8: Launch Services Program (VA)
Overview

- **Overview of LSP**
  - 12 years old
  - Handles most of NASA's robotic launches
  - Acts as a form of insurance for NASA's payloads by providing technical support to contracted companies
- **Multi-Operational Support Building (MOSB) & Payload Hazardous Servicing Facility (PHSF)**
  - Payload integration and testing site
  - Class 10,000 laminar flow clean room
- **Hangar AE**
  - Launch Vehicle Data Center used by contractors on launch day
- **Tour of Cape Canaveral Launch Sites**
  - History of launches: Mercury, Gemini, Apollo, and Shuttle

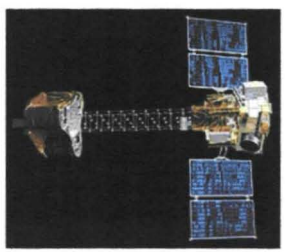
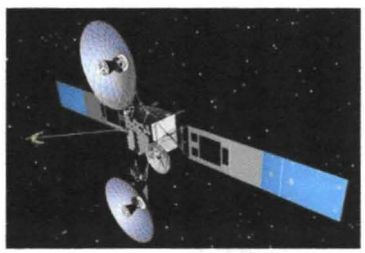
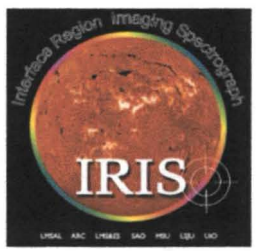
Day 8: Launch Services Program (VA)

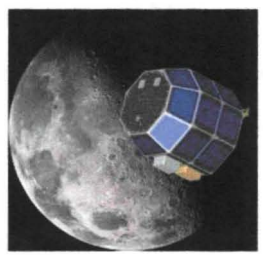
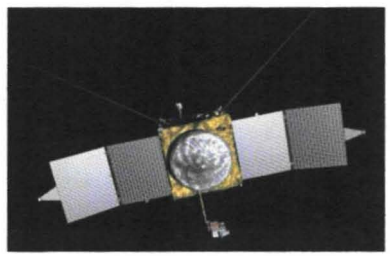
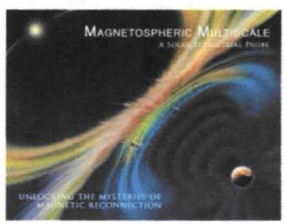
Design vs Operability

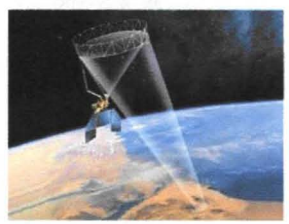
- LSP is a long-term investment by NASA
- Certifies design of vehicle to ensure future operability of vehicle
- Does not own any launch hardware, so does not have direct control over design of vehicle, but able to make suggestions

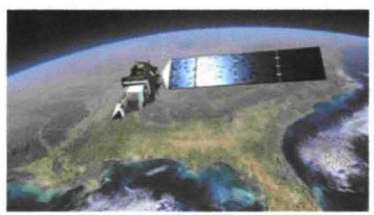
Day 8: Launch Services Program (VA)
Past, Present, and Future

- Have launched many of NASA's historic missions such as Mars Exploration Rovers, Cassini, Juno, and Kepler
- Recent notable missions include GRAIL and Mars Science Laboratory
- Many missions for the future including NuStar, IRIS, LADEE, and MAVEN, and ISS resupply missions
- LSP's mission remained mostly unchanged after the retirement of the Shuttle





Day 8: Launch Services Program (VA)

Acknowledgements

- Jenny Lyons
- Albert Sierra
- Brent Seale
- Reed Divertie
- Karen Childree
- Nate Wood

Day 9: ISS Ground Processing

Libby Jones

My Experience

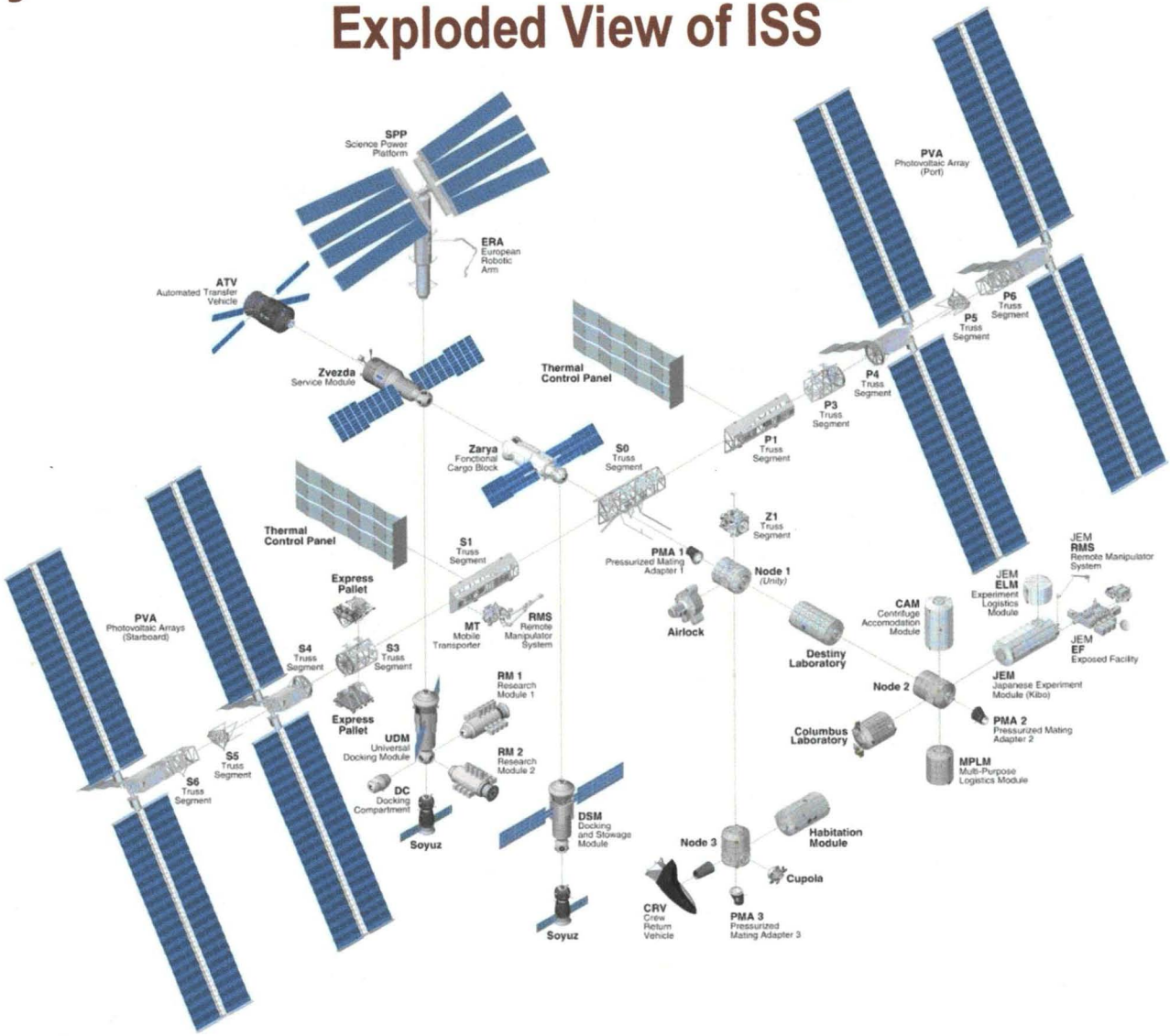
- **Background**
  - Sophomore in AeroAstro
- **Why I came**
  - Desire to learn how an engineering workforce operates
  - Interested in seeing where NASA is headed after the Shuttle program
- **What I got out of it**
  - Engineering is just one (small) part of the picture
  - NASA is still very busy despite the many changes it is going through

Day 9: ISS Ground Processing & Research

- **ISS Overview**
  - 32 missions to build over 10.5 years
  - Occupied continuously for over 11 years
  - Partnership among five countries
    - NASA, ROSCOSMOS, JAXA, ESA, CSA
  - Commercial companies now getting involved
    - Orbital: Taurus II rocket with Cygnus spacecraft (unmanned)
    - SpaceX: Falcon 9 rocket with Dragon spacecraft (manned or unmanned)
- **NSPIRES (NASA Solicitation and Proposal Integrated Review and Evaluation System)**
  - Solicitations for proposals
  - RPWG (Research Planning Working Group) decides when experiments will fly

Day 9: ISS Ground Processing & Research

Exploded View of ISS

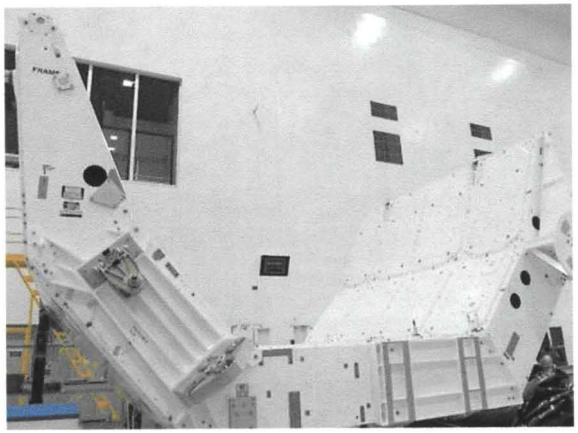


Day 9: ISS Ground Processing & Research
Research Hardware

- **Racks**
  - ExPrESS (Expedite the Processing of Experiments for Space Station Research) Racks
  - HRF (Human Research Facility) Racks
  - CIR/FIR (Combustion/Fluids Integrated Rack)
- **EUE (Experiment Unique Equipment)**
  - BRIC (Biological Research In Canisters)
    - PDFU (Petri Dish Fixation Units)
    - PDFU Actuator Attachment for fixation
  - ABRS (Advanced Biological Research System)
    - LEDs for plant growth
    - GIS (GFP (Green Fluorescent Protein) Imaging System)

Day 9: ISS Ground Processing & Research

High Bay Tour

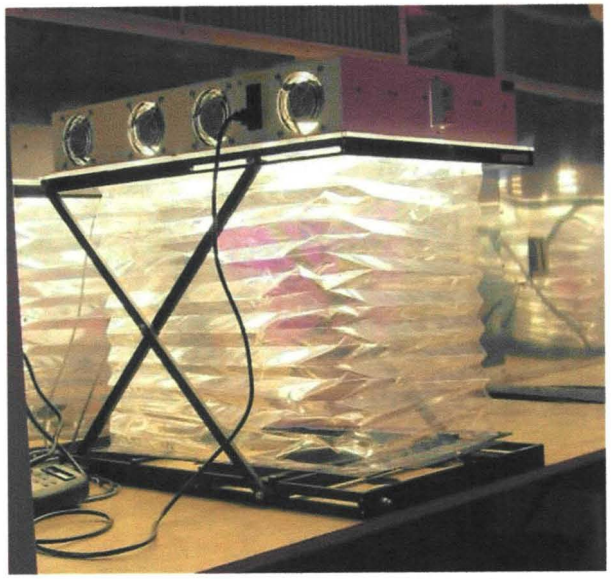


SLP (SpaceLab Pallet)

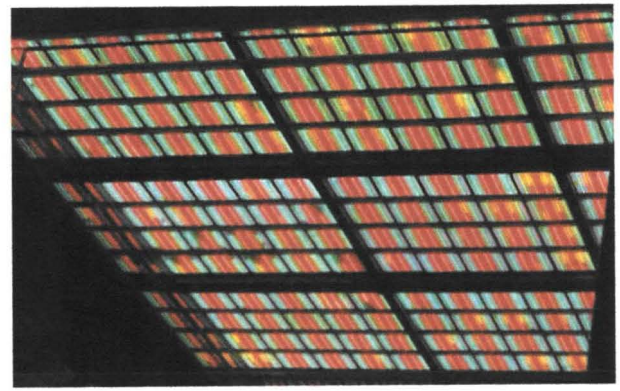
MLPM FM-2 (Multi-Purpose Logistics Module)

MLPM FM-3

Day 9: ISS Ground Processing & Research
SLSL (Space Life Sciences Lab) Tour



- **VEGGIE**
  - Collapses to save room in spacecraft
  - Grows with plants



- **VCD (Vapor Compression Distillation)**
- **Nitrogen fixation by legumes**
- **"Free" light**
- **MBR (Membrane Bioreactors) – hollow fiber membrane system for purifying urine**

Day 9: ISS Ground Processing & Research

Past, Present, and Future

- **ISS designed from the start for long-term operation**
- **Lessons learned about design from past stations**
  - SpaceLab
  - Mir
  - Skylab
- **Phases of ISS use**
  - Assembly: November 1998 – May 2010
  - Habitation: November 2000 – present
  - Research: ongoing; expected to peak in 2015

Day 9: ISS Ground Processing & Research
Acknowledgements

- Jose Nuñez
- Dr. Ray Wheeler
- ISS Ground Processing Team

Concluding Remarks

Summary

- Shuttle program has ended, but there's still so much going on at KSC
- Commercial companies
- Exploration beyond LEO (SLS, Orion)
- More flexible designs
- Streamlined operations
- ISS Science Experiments

Acknowledgements

- Thank you to *everyone* who made this program possible! We had a blast!
- Russell Romanella
- Jon Cowart
- Les Gold
- Mr. Rob Smith
- Education Office
- Badging Center
- Special thanks to *Helen Kane* and *Raji Patel* for all their hard work and dedication

Thank you!